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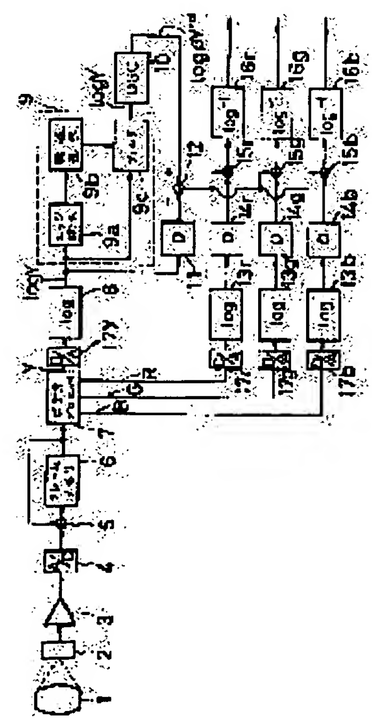
(54) IMAGE SIGNAL PROCESSOR

(57)Abstract:

PURPOSE: To provide an image processing circuit by which uneven illumination can be eliminated or suppressed without emphasizing unnaturally its edge, even in a place in which is luminance is varied stepwise.

CONSTITUTION: A processor is provided with a filtering circuit 9c for performing filtering to an image signal subjected to logarithmic compression, a filtering characteristic setting circuit 9b for setting adaptively a band pass characteristic of this filtering circuit 9c at every position of an image in accordance with a feature of the image signal, and a dynamic range/gain controller 10 for executing control of a dynamic range and gain with respect to the signal to which filtering is performed.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the picture signal processor which performs the image processing which controls lighting unevenness etc.
[0002]
[Description of the Prior Art] In a general CRT monitor, the dynamic range which can be displayed is about 46dB. Therefore, even if it is going to display an image with a dynamic range larger than this, i.e., the big image of the difference of light and darkness, the bright place of the image and a dark place cannot be displayed on coincidence.
[0003] For example, by the image by the endoscope (it is described as an electronic scope below) of the electronic formula which displays the electric picture signal which carried out photo electric conversion using solid state image sensors, such as CCD, on a CRT monitor, since lighting is close to the point light source, the difference of distance serves as big lighting unevenness, a near photographic subject causes halation strongly in the screen of one sheet, and the phenomenon in which a far photographic subject is dark and nothing is seen occurs.
[0004] As a means to solve the above phenomena, the picture signal amendment circuit using a two-dimensional filter as shown in JP,62-132479,A is proposed.
[0005]
[Problem(s) to be Solved by the Invention] After controlling low-pass [of spatial frequency] using a two-dimensional filter, the effect of lighting unevenness is made to mitigate through a series of actuation of changing into an exponential property, in the above-mentioned picture signal amendment circuit, while carrying out logarithmic compression of the luminance signal of a picture signal and enabling it to display the image of a large dynamic range. Like an endoscope, the low-pass control by this two-dimensional filter is very effective, when change of the amount of illumination light is gently-sloping.
[0006] However, about common images other than an endoscope, if many so-called edge parts may exist and near the profile of the case where the illumination light is a step-like, or a photographic subject etc. performs the above processings to such an image, the edge will be emphasized unnaturally and will become unsightly.
[0007] The picture signal processor of this invention was made paying attention to such a technical problem, and the place made into the purpose is to offer the picture signal processor which can remove or control lighting unevenness, without brightness emphasizing the edge unnaturally also in the location which is changing in the shape of a step.
[0008]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the picture signal processor of this invention possesses the logarithmic-compression means which carries out logarithmic compression of the picture signal including a color signal, a filtering means filter to the picture signal by which logarithmic compression was carried out, a filtering property setting means set up the band-pass response of said filtering means accommodative according to the description of a picture signal, and the dynamic range gain control means that performs control of a dynamic range and gain to the signal to which said filtering was given.
[0009]
[Function] That is, according to this invention, it filters, after carrying out logarithmic compression of the inputted picture signal, and it changes into an exponential property. According to the description of a picture signal, a band-pass response is controlled accommodative in the case of this filtering. From this, more, it will be

controlled by filtering to a high region and controlled in the place where brightness is changing in the shape of a step, without not only the lighting unevenness of low frequency but step-like lighting unevenness becoming unnatural. Therefore, the good image of contrast with large latitude is displayed on a monitor.

[0010]

[Example] Drawing 1 is the block diagram of the 1st example which applied the picture signal processor of this invention to the electronic camera which can picturize the large photographic subject of a dynamic range using accumulation. It is a solid state image sensor for changing into an electrical signal the image which carried out 1 with the optical lens and carried out image formation of 2 with the optical lens. After the picture signal read from the solid state image sensor 2 is amplified by level predetermined with a preamp 3, digital coding of it is carried out with A/D converter 4.

[0011] The picture signal by which digital coding was carried out is memorized one by one by the frame memory 6 for every frame through an adder 5. The above-mentioned adder 5 carries out accumulation of the picture signal read one by one on a frame memory 6 in adding the picture signal by which storing storage was carried out, and the picture signal of one frame as follows read from said solid state image sensor 2 one by one to this frame memory 6, and re-writing in the above-mentioned frame memory 6. Expansion of the dynamic range of the picture signal is achieved by repeating the accumulation of such a picture signal the number of predetermined times, and performing it. Since Japanese Patent Application No. No. 334508 [one to] has a detailed publication about the dynamic range expansion approach in this image pick-up, it omits here.

[0012] If accumulation is used as mentioned above, a photographic subject with a 80dB dynamic range can be picturized using the solid state image sensor 2 which has a 50dB dynamic range, for example.

[0013] Thus, in order to display the acquired 80dB picture signal on a picture monitor like TV receiving set, the dynamic range of a picture signal must be compressed according to the dynamic range (for example, 46dB) of a picture monitor.

[0014] Therefore, a picture signal is divided into a luminance signal Y and each chrominance signals R, G, and B by the video processor 7. D/A-converter17y, 17r, 17g, and 17b After changing into an analog signal After it carries out logarithmic transformation of the luminance signal Y with logarithmic amplifier 8 (log Y) and the adaptation filter 9 removes lighting unevenness (log Y'), A multiplier alpha adjusts the dynamic range of an image according to the dynamic range (46dB) of a picture monitor by the dynamic range gain controller (DGC) 10. With a multiplier log beta, the gain which amplifies the picture signal level which turned into a low by average-value subtraction is adjusted, and an output and logbetaY'alpha are obtained. This signal and log beta Y'alpha have the signal log Y which has passed through the delay circuit 11 of the same time amount as being processed by the above-mentioned filter 9 and DGC10 reduced in a subtractor 12. The signal of the compression coefficient for taking advantaging of a chrominance signal as shown in a-one number from this is made.

[0015]

[Equation 1]

$$\log\beta Y'^{\alpha} - \log Y = \log(\beta Y'^{\alpha} / Y)$$

the above-mentioned adaptation filter 9 -- edge detector 9a, the property selection circuitry nine b1, and filter 9c1 from -- it changes. Drawing 2 expressed the example of the adaptation filter 9. Actuation of the adaptation filter 9 is explained based on drawing 2 .

[0016] They are an output from logarithmic amplifier 8, and log Y (referred to as =y (x).) at drawing 2 . However, x is delayed by 4 pixels through the delay circuits 910-913 for 1 pixel on the horizontal position coordinate of a pixel. This signal is set to y (x0). In an adder 920, a total of a 4-pixel pixels [9 pixels] signal is added approximately focusing on the pixel y (x0) currently outputted to the delay circuit 913, and it doubles 1/9 with a multiplier 924. That is, it becomes the partial average of a 9-pixel signal.

[0017] Similarly with an adder 921 and a multiplier 925 Pixel y (x0) and approximately [its] 3 pixels each, Pixel y (x0) and approximately [its] with the partial average, the adder 922, and multiplier 926 of a total of a 7-pixel signal 2 pixels each, Pixel y (x0) and the partial average of a total of a 3-pixel signal before and behind that are acquired with the partial average, the adder 923, and multiplier 927 of a total of a 5-pixel signal, and it becomes the input of a selector 929, respectively.

[0018] Edge detector nine a1 enclosed with the broken line on the other hand The main pixel y (x0) then outputted from a delay circuit 913 is doubled two with a multiplier 902, and the pixel before and behind that is

doubled -one with a multiplier 903,901, respectively, and is added with an adder 904. An absolute value is taken for the output of an adder 904 with the absolute value vessel 905, and this is set to edge signal e (x) showing the magnitude of an edge. A convolution operation is carried out using the multiplier to luminance-signal y (x) (- 1, 2, -1), and actuation of this edge detector takes that absolute value. If this is expressed with a formula, it will become like several 2.

[0019]

[Equation 2]

$$e(x) = |y(x) * h(x)|、$$

ここで、h (x) は (−1, 2, −1) なる係数である。

It is a time of an edge big when large having e (x) here, and when small, it is at the small time of change of brightness. e (x) is the property selection circuitry nine b1. It is inputted. property selection circuitry nine b1 **** -- according to the magnitude of e (x), a signal is sent to said selector 929. In a selector 929, four kinds of averages of the partial average width of face 3, 5, 7, and 9 can be chosen. property selection circuitry nine b1 from -- e (x) is narrow in partial average width of face, when large, and a signal is sent to a selector 929 so that partial average width of face may become [e (x)] large, when small. After the output of a selector 929 is carried out with a multiplier 928 a times (however, referred to as a= 0.5 0<=a<=1 and here), in a subtractor 930, it is reduced from the output y from said delay circuit 913 (x0), and is sent to DGC10 as logY'=y' (x). If actuation of the filter of a top Norikazu ream is expressed with a formula and partial average width of face will be made into w pixels, it will become like several 3.

[0020]

[Equation 3]

$$y'(x) = y(x) - a \cdot (1/w) \sum_{i=x-w/2}^{x+w/2} y(i)$$

That is, the average subtraction mold filter which subtracts the average of the pixel from pixel value y (x) to order partial average width of face is constituted.

[0021] The multiplier a by which the partial average can be multiplied determines the strength of the effectiveness of a filter. If said number 1 formula is expressed with a convolution operation with a rect function, the following several 4 will be obtained.

[Equation 4]

$$\begin{aligned} y'(x) &= y(x) - (a/w)\,\mathrm{rect}(x/w) * y(x) \\ &= y(x) * \{\delta(x) - (a/w)\,\mathrm{rect}(x/w)\} \end{aligned}$$

Drawing 3 shows delta(x)-(a/w)rect (x/w).

[0022] Furthermore, if the Fourier transform of several 4 is carried out, the following several 5 will be obtained.

[0023]

[Equation 5]

$$y'_f(u) = y_f(u)\,\{1 - a \cdot \mathrm{sinc}(wu)\}$$

1-a-sinc (wu) is shown in drawing 4 . u is spatial frequency here.

[0024] Drawing 4 , i.e., it is the property which controls the low frequency region used as the property of this filter where lighting unevenness exists, is known. Control becomes strong, so that a multiplier a is large.

[0025] Moreover, the frequency controlled by choosing the partial average width of face w smaller like w'=w/2 can be extended to a high region.

[0026] Change of the property of the filter accompanying change of w is shown in drawing 5 . In drawing 5 , it is a= 1, and an axis of abscissa is a Nyquist rate 1.0 It has normalized by carrying out.

[0027] According to drawing 5 , if w becomes small, in the normalized spatial frequency, it will be controlled to a mid-range. By the way, the frequency component which forms the description of an image is distributed near

the mid-range of the normalized spatial frequency in many cases. Moreover, the ununiformity of the illuminance by the lighting in the whole photographic subject and the so-called lighting unevenness are distributed over low-pass [of the above-mentioned spatial frequency] in many cases. Therefore, it is effective for reduction of lighting unevenness to set up w greatly and to control only low frequency.
[0028] However, if only low frequency is controlled when an edge exists in an image, the edge will be emphasized too much and will serve as an unnatural image.
[0029] The picture signal before filtering to drawing 10 and the picture signal after filtering are shown repeatedly. In drawing 10 , it is a signal before a continuous line filtering, and it applies to the right from the left and there is an edge of ** -> dark. A broken line is the wave after filtering said partial average width of face w= 9, it applies near an edge from a part without brightness change, and overshoot and undershooting are seen. An alternate long and short dash line is a wave after filtering when being referred to as w= 3, and compared with w= 9, overshoot and also undershooting are small and it is understood are filtered without disturbing a original wave.
[0030] Thus, in a place without an edge, w is set up greatly, the frequency component of an image is saved, only the low band by the ununiformity of lighting is controlled, near an edge, too much emphasis of an edge cannot be caused but lighting unevenness can be effectively controlled by setting up w small.
[0031] As mentioned above, by work of the edge detector nine a1, the property selection circuitry nine b1, and a selector circuit 929, when there is a big edge, a filter with said small partial average width of face is chosen, it controls to high frequency, and the bad influence to the edge section is reduced. Moreover, when there is no edge, it has composition which chooses a filter with large partial average width of face, and controls only low frequency. Although maximum of the partial average width of face w of a filter was set to 9 and it made adjustable [of w] into four steps in this example, it is good also as a configuration which enlarged maximum of w further and increased that adjustable phase.
[0032] In addition, said-three number is rewritten like the following several 6.
[0033]
[Equation 6]

$$y'(x) = y(x) - a \cdot (1/w) \sum_{i=x-w}^{x+w} y(i)\, k(i+x)$$

$$\text{但し } k(x) = \mathrm{rect}(x/w)$$

This k (i) is shown in drawing 13 . Moreover, in this k (i), if a spline function like drawing 14 or the sinc function which is not illustrated is used, a ripple which is looked at by the frequency characteristics of the filter of drawing 5 will be controlled.
[0034] Zero frequency is changing so that drawing 4 may show, and the picture signal filtered as mentioned above is adjusted so that gain may become good by the monitor display by DGC10.
[0035] On the other hand, it is separated by the video processor 7 by drawing 1 , and they are D/A-converter17r, 17g, and 17b. The chrominance signals R, G, and B changed into the analog signal They are logarithmic amplifier 13r, 13g, and 13b, respectively. Logarithmic transformation is carried out and they are delay circuit 14r, 14g, and 14b. Only time amount until the above-mentioned compression coefficient is made is delayed, and they are adder 15r, 15g, and 15b. It sets and is added with the above-mentioned compression coefficient. This will become the same thing as having calculated the following several 7, if R signal is taken for an example.
[0036]
[Equation 7]

$$\log R + \log(\beta Y'^{\alpha}/Y) = \log(R \cdot \beta Y'^{\alpha}/Y)$$

They are reverse logarithmic amplifier 16r, 16g, and 16b further about this. Since inverse logarithm conversion is carried out, it becomes R-beta Y'alpha/Y (in the case of R signal), and it is a compression coefficient to chrominance signals R, G, and B. It means multiplying by beta Y'alpha/Y.
[0037] Thus, a dynamic range is compressed and it displays on a monitor.
[0038] As mentioned above, without starting unnatural edge enhancement, since the filter controlled more to high frequency in the edge section of a picture signal according to a series of operations of the adaptation filter 9 according to the magnitude is chosen, it becomes possible to remove lighting unevenness, it becomes possible

to lower the compressibility of the dynamic range by DGC10, and a good image with contrast is displayed.
[0039] Next, in the adaptation filter 9 of the 1st example, the 2nd example which changed the configuration of edge detector 9a is explained with reference to drawing 6 .
[0040] In this example, edge signal e (x) is obtained like said 1st example through a multiplier 901,902,903, an adder 904, and the absolute value machine 905. This signal expresses the magnitude of a difference with a contiguity pixel, i.e., the magnitude of an edge. Every 1 pixel edge signal e (x) is delayed in delay circuits 931-938, respectively. It centers on the edge signal e (x0) outputted from a delay circuit 934. e which is equivalent to 4 pixels before and after [respectively] that (x0-4) -- e (x0) -- About nine e (x) of e (x0+4), multipliers 941-948, It outputs to property selection-circuitry 9b, asking for the main load sum with an adder 949, and using the above-mentioned main load sum as edge information signal E (x). E (x) is expressed with several 8 when edge information detection width of face is set to S.
[0041]
[Equation 8]

$$E(x) = \sum_{i=-S/2}^{S/2} e(x+i) \cdot C(i)$$

However, C (i) is a function as shown in drawing 7 , and it serves as a load factor which becomes small as the distance from a core increases. It is the location x1 of the edge information detection width of face S within the limits to the location x of the pixel which is S= 9 in this example. If a big edge exists, the edge signal e (x1) will serve as a big value. according to several 3 -- xx1 since it receives, and the load factor is large when near -- E (x) -- large -- becoming -- xx1 from -- since the load factor is small set up when it is in the distance by detection width-of-face S within the limits, E (x) becomes small. That is, edge information signal E (x) also includes the far and near information on an edge.
[0042] property selection circuitry nine b2 **** -- the magnitude of edge information signal E (x) -- responding -- filter 9c2 Delivery and the optimal partial average width of face are chosen as the inner selector 929 for a signal. The magnitude of E (x) and the relation of partial average width of face are shown in drawing 15 . That is, E (x) is small in partial average width of face, when large, and it operates so that E (x) may enlarge partial average width of face, when small.
[0043] As mentioned above, a series of actuation enables it to control the lighting unevenness of the whole image, without carrying out unnatural emphasis near an edge, and a good image is obtained.
[0044] Since according to this example the partial average width of face of a filter becomes small continuously as an edge approaches, the image of more natural sensibility is obtained.
[0045] Although edge detection width of face S is set to 9 in this example, this may be further made large or you may narrow. Moreover, although considered as the configuration also with the linear multiplier of the load sum, a multiplier may be suitably changed in addition to this.
[0046] Moreover, edge information signal E (x) may be normalized by the average of an image etc. Next, filter 9c in drawing 1 is explained with reference to drawing 8 about the 3rd example considered as the simpler configuration.
[0047] Nine a2 It is an edge detector and is the same configuration as what was stated in the 2nd example. 9c3 enclosed with a broken line A part is equivalent to filter 9c of drawing 1 . From inputted signal y (x), it is the edge detector nine a2. As the 2nd example stated by the way, edge signal e (x) is outputted.
[0048] On the other hand, it is a filter 9c3. In inside, every 1 pixel is delayed in delay circuits 910-917, respectively. If the signal outputted from a delay circuit 913 is made into the main pixel y (x0), the signal for 3 pixels including y (x0-1) outputted from the delay circuits 912 and 914 before and behind that and y (x0+1) will be added with an adder 954, and will be outputted to an adder 958. It is added with an adder 953 and y (x0-2) and y (x0+2) which are outputted from delay circuits 911 and 915 are the property selection circuitry nine b3 with a multiplier 957. After being able to multiply by the value outputted, it is sent to an adder 958. It is added with an adder 952 and y (x0-3) and y (x0+3) which were outputted from delay circuits 910 and 916 are the property selection circuitry nine b3 with a multiplier 956. After being able to multiply by the value outputted, it is sent to an adder 958. the output y (x0+4) of y (x0-4) inputted into the delay circuit 910 and a delay circuit 917 is added with an adder 951 -- having -- a multiplier 957 -- property selection circuitry nine b3 from -- after being able to multiply by the value outputted, it is sent to an adder 958. Said four inputs are added in an adder 958, and it outputs to a multiplier 959, and is the property selection circuitry nine b3 with a multiplier 959. It

multiplies by the value outputted and outputs to a subtractor 930. In a subtractor 930, the value of the output of the multiplier 959 which is the partial average is subtracted from the output y from a delay circuit 913 (x0).
[0049] the above-mentioned property selection circuitry nine b3 Edge detector nine a2 from -- according to the magnitude of edge information signal E (x), as shown in drawing 16 , it outputs. Thereby in drawing 16 , a can adjust the effectiveness of a filter by the multiplier of 0<=a<=1.
[0050] As mentioned above, edge detector 9a, the property selection circuitry nine b3, and a filter 9c3 Without causing a bad influence near an edge with a easier configuration with combination, the whole lighting unevenness can be removed effectively and a good image can be obtained.
[0051] Next, the 4th example using the direction signal ed of an edge (x) with which the sense (** -> dark or dark -> **) of edge information signal E (x) and an edge is expressed to the input of a property selection circuitry is described.
[0052] Drawing 9 shows the configuration of the 4th example of this invention. Filter 9c3 Filter 9c3 of the 3rd example in drawing 8 It is the completely same configuration. Edge detector nine a4 Edge detector nine a2 of the 2nd example in drawing 6 The output of an adder 904 is made into the direction signal ed of an edge (x). As for the time of ** -> dark, change of brightness [in / in ed (x) / an edge] just becomes, and it becomes negative at the time of dark -> **. ed (x) is the property selection circuitry nine b4 in E (x) in order to tell the information on the same pixel as E (x), after being delayed by 4 pixels in the delay circuit 960. It is supplied.
[0053] property selection circuitry nine b4 **** -- as shown in drawing 17 , when the direction signal ed of an edge (x) is forward, about the value of a, it becomes small at the time of negative [large] -- as -- 0.3 from -- 0.7 It is made to change in between. The value shown in drawing 16 is outputted to inputted edge information signal E (x), and the property of a filter is determined.
[0054] Drawing 11 shows the wave before and behind filtering when being referred to as w= 3. In a continuous line, a broken line expresses the wave after filtering before filtering. The plot on a line expresses 1 pixel. Near an edge, even if w= 3 is chosen by edge information signal E (x), if an edge becomes steep as shown in drawing, big overshoot and undershooting will appear in the wave after filtering by it. The case where used the direction signal ed of an edge (x) on the occasion of filtering, and the multiplier a of a filter is changed accommodative like this example at it is shown in drawing 12 . Among drawing, in the pixel of O, the direction signal ed of an edge (x) shows a forward big value, and a= 0.65 is chosen. Moreover, in the pixel of **, ed (x) serves as negative, and it is a= 0.4. It is chosen, and it is filterable like a broken line, controlling overshoot and undershooting.
[0055] Next, the 5th example of this invention constituted from a digital circuit is explained.
[0056] The block diagram of this example is shown in drawing 18 . In this drawing, a video processor is the same configuration as drawing 1 . the luminance signal Y outputted from the video processor 7 -- a logarithm -- removal of lighting unevenness and compression of brightness are performed by a circuit 8, the adaptation filter circuit 9, and the dynamic range gain controller 10. 20 is a subtractor, 21 is an inverse logarithm circuit, and the multiplier by which each signal of R, G, and B is multiplied from this is outputted. The multiplier for compression multiplies by 22r, 22g, and 22b with a multiplier.
[0057] Moreover, the adaptation filter circuit 9 consists of the band setting circuit 23 for detecting lighting unevenness, the band adjustable LPF (Low Pass Filtering) circuit 24, the square average detecting element 25 for generating the multiplier n by which this output is multiplied and the multiplier setting circuit 26, a multiplier 27, and a subtractor 28 for subtracting the detected lighting unevenness.
[0058] Moreover, the band setting circuit 23 and the band adjustable LPF circuit 24 have composition of drawing 19 . That is, it is edge signal e (x) which consists of edge detector 9a for detecting the edge signal of Signal log Y, and property selection-circuitry 9b, and is further outputted from the Laplacian circuit where edge detector 9a performs the two-dimensional Laplacian operation, the absolute value detector 30 which calculates an absolute value, and this absolute value detector 30. It consists of a low pass filter circuit 31 which performs two-dimensional low-pass filtering, and is edge information signal E (x). It outputs. moreover, property selection-circuitry 9b -- edge information signal E (x) from -- W which is the multiplier which determines a band band adjustable [LPF] is outputted based on a property like drawing 20 . Moreover, band adjustable [LPF / 24] is constituted by the Gaussian multiplier selection circuitry 32 and the convolution circuit 33. A Gaussian multiplier selection circuitry chooses the several 9 following multiplier by W outputted from a property selection circuitry (refer to drawing 21).
[0059]

[Equation 9]

$$K(x) = A e^{-c\left(\frac{2}{W}x\right)^2}$$

c is a suitable multiplier by this formula, and A is obtained as the following several 10.
[0060]
[Equation 10]

$$A = 1 \Big/ \sum_{x=-\frac{W}{2}}^{\frac{W}{2}} e^{-c\left(\frac{2}{W}x\right)^2}$$

In addition, although this formula is expressed with one dimension of x, it is two-dimensional in fact. This A is a multiplier for adjusting change of the intensity level by the difference in W, and it is set up so that total of the multiplier value of a Gaussian multiplier may be set to 1.
[0061] Since when a band setting circuit has many edges or they are near chooses small W, the low-pass effectiveness band adjustable [LPF] becomes small. Moreover, since when there are few edges or they are far selects big W, the low-pass effectiveness band adjustable [LPF] becomes large. Moreover, in the square average detecting element 25 and the multiplier setting circuit 26, the multiplier n (n<=1) by which it multiplies to the signal by which low-pass filtering was carried out with band adjustable [said / LPF] is called for. This multiplier n is the value Rpower as which the square average of output log Y' of the adaptation filter circuit 9 is inputted into the multiplier setting circuit 26. It is decided that it becomes.
[0062] By multiplying by this multiplier, the square average of log Y', i.e., power, becomes fixed. That is, to a photographic subject with large lighting unevenness, n becomes large, control of lighting unevenness works greatly, n becomes small to a photographic subject with small lighting unevenness, and control of lighting unevenness becomes weaker. Becoming like the following several 11, if this adaptation filter is expressed with a formula, a band property becomes like drawing 22 .
[0063]
[Equation 11]

$$\log Y' = \log Y - n \cdot (\log Y) * \left(A \cdot e^{-c\left(\frac{2}{W}x\right)^2}\right)$$

＊はコンボリューションを表す

That is, when the amount of edges is small, W becomes large and controls only the low-frequency component equivalent to lighting unevenness. Moreover, when the amount of edges is large, W becomes small and controls to a mid-range more. Moreover, n is changed according to the absolute magnitude of lighting unevenness, and adaptive filtering is performed so that the power of log Y' may become fixed. Since the Gaussian filter is used as a band adjustable filter here, change of a filter shape is monotone change, there is no ripple like drawing 5 and there is no fear of being generated [artifact] in the image of filtering.
[0064] moreover, the dynamic range controller 10 -- the average ave and the set point Rave from the average detecting element 34 from -- it is constituted by the multiplier setting circuit 35 for setting up the addition multiplier log beta, the standard deviation detecting element 36, the multiplier setting circuit 37 for setting up the multiplication multiplier alpha from standard deviation SD and the set point RSD, and a multiplier 38 and an adder 39. The multiplier setting circuits 35 and 37 generate a multiplier so that the average and standard deviation of an output signal of DGC10 may be respectively set to Rave and RSD.
[0065] Next, an operation of this example is explained. The digital signal which accumulation was carried out and was inputted is the video processor 7, and is divided into a luminance signal Y and each signal of R, G, and B. Suppose that the dynamic range of a luminance signal Y is about 75dB here. In the adaptation filter circuit 9, the amount of edges is detected as mentioned above, accommodative filtering is performed according to this, and log Y' is outputted. This log Y' is Rpower so that a dynamic range may be controlled by about 50-60dB. The value is set up. And log Y' is inputted into the DGC circuit 10, a dynamic range and gain are adjusted and

the Y " of the several 12 signals as follows is outputted so that a dynamic range may compress into 45-50dB which is the dynamic range of a monitor by already set-up Rave and RSD.
[0066]
[Equation 12]

$$Y'' = \alpha \log Y' + \log B$$

And the multiplier (= Y'alpha-beta/Y) by which multiplication is carried out with Multipliers 22r, 22g, and 22b is outputted by a subtractor 20 and the inverse logarithm circuit 21. And if R signal is taken for an example, the several 13 following calculated value will be outputted.
[0067]
[Equation 13]

$$R \times \frac{Y'^{\alpha} \cdot \beta}{Y}$$

Thus, the signal with which the dynamic range was compressed is displayed on a monitor.
[0068] Control of lighting unevenness is performed by the adaptation filter 9 above, a dynamic range is compressed by DGC10, and the subject-copy image of a large dynamic range can be displayed as a good image which has contrast on a monitor.
[0069] Moreover, Rpower About the degree of control of lighting unevenness, it is Rave. Since the compressibility of DGC can be adjusted by RSD, a favorite image can be displayed by each people by using the controller 40 which controls these three parameters Rpower, Rave, and RSD from the outside to be shown in drawing 23 .
[0070] Moreover, according to the pattern and class of photographic subject, a good display can carry out to any photographic subjects by using the pattern detector 41 which controls this Rpower, Rave, and RSD accommodative like drawing 24 . The intellectual processing which used the neural network performs this pattern detection.
[0071] Moreover, in this example, since the Gaussian filter is used for band adjustable LPF, filtering with the filter shape which a ripple does not produce in respect of a frequency can be performed, and a good image can be obtained.
[0072] moreover, edge information signal E (x) from -- although it depended on the property shown at drawing 20 in this example choosing the characteristic value W of a Gaussian multiplier, it may connect to the histogram of an edge information signal etc., and a property may be changed.
[0073] Below, the 6th example of this invention which simplified circuitry more is explained. The block diagram of this example is shown in drawing 25 . As for the luminance signal Y outputted from the video processor 7, removal of lighting unevenness and compression of brightness are performed by logarithmic amplifier 8, the adaptation filter circuit 9, and the dynamic range gain controller 10. 20 is a subtractor, 21 is an inverse logarithm circuit, and the multiplier by which each signal of R, G, and B is multiplied from this is outputted. The multiplier for dynamic range compression multiplies by 22r, 22g, and 22b with a multiplier.
[0074] the output of a multiplier 44 for an adaptation filter circuit 9 to multiply the output of HPF 43 by the output of the multiplier setting circuit 42 which sets up the multiplier by which the output of HPF (High Pass Filter)43 and HPF43 which extracts the high frequency component of the level detector 40 which detects the average level of the value of the near pixel of the pixel to observe, and an image multiplies with the output of a level detector 40, and a multiplier setting circuit 42, and a multiplier 44 -- a logarithm -- it consists of an adder 45 which adds to the output logY of a circuit 8.
[0075] The level detector 40 is a convolution filter, for example, performs a convolution operation to the output logY from logarithmic amplifier 8 using the multiplier of 3x3 as shown in drawing 26 .
[0076] HPF43 is realizable with the convolution filter using the multiplier of 3x3 as shown in drawing 27 .
[0077] The average level near the attention pixel is detected by the level detector 40, and, as for logY outputted from logarithmic amplifier 8, the multiplier to the pixel is determined in the multiplier setting circuit 42 from the output. In the multiplier setting circuit 42, average level outputs a small value for a big value to a pixel with small average level to a large pixel.
[0078] On the other hand, in a multiplier 44, it multiplies by the multiplier obtained in the above-mentioned multiplier setting circuit 42, and further, in an adder 45, the output of the above-mentioned multiplier 44 is

added and is outputted to the output logY of logarithmic amplifier 8 at the high frequency component of logY obtained by HPF43.

[0079] The above-mentioned output controls a dynamic range by the multiplier alpha and logbeta in DGC10. under the present circumstances, the luminance signal Y -- receiving -- beta-Y -- alpha -- a dynamic range is controlled with input-output behavioral characteristics. The input-output behavioral characteristics of the RF at the time of compressing a dynamic range into drawing 28 are shown. In case a dynamic range is compressed, like drawing 28 , as for a high intensity level, a compression ratio becomes large rather than a low intensity level, and the contrast in a high intensity level will fall. However, a good image is displayed on a monitor, without the contrast at the time of compressing a dynamic range falling in the adaptation filter circuit 9, beforehand, since the high frequency component of a high intensity level is emphasized. Moreover, since the window width of the convolution filter to be used is as small as 3x3, the effect of overshoot of near an edge or undershooting is also small.

[0080] Moreover, it is good also as a configuration like drawing 29 which omits the level detector 40 in drawing 25 in order to simplify circuitry further, and considers the output of logarithmic amplifier 8 as the input of the multiplier setting circuit 42 directly.

[0081] According to this example, even if the same effectiveness as lighting unevenness control is acquired and it uses the adaptation filter circuit 9 as a 2-dimensional filter, without causing the contrast fall of the image after dynamic range compression by emphasizing the high frequency component of a high intensity level before dynamic range compression, it can realize with an easy configuration and equipment can be made cheaply.

[0082] The 7th example of this invention which sets up the multiplier at the time of furthermore emphasizing a high frequency component more accommodative is explained.

[0083] The block diagram of this example is shown in drawing 30 . The adaptation filter 9 of this example consists of the level detector 40, the accommodative multiplier setting circuit 46, HPF43, a multiplier 44, and an adder 45. Among these, since the same work as the example of drawing 25 is carried out except accommodative multiplier setting circuit 46, explanation here is omitted.

[0084] The accommodative multiplier setting circuit 46 is changed into the weighting factor of RF emphasis of the average level which is the output of the level detector 40. In this case, a translation table is switched using the multiplier alpha obtained by DGC10, and logbeta.

[0085] Input-output behavioral characteristics when alpha changes to drawing 31 are shown.

[0086] Like drawing 31 , since the high frequency component of an input signal with high average level is compressed with bigger compressibility than a high frequency component with low average level when smaller than 1, alpha chooses a translation table which outputs a small multiplier value in the accommodative multiplier setting circuit 46, when the output of a multiplier value big when the output of the level detector 40 is big, and the level detector 40 is small.

[0087] However, when alpha takes the value near 1, a difference is lost in the place where compressibility is as low as the high place of average level. In that case, the same value is outputted irrespective of the size of the output of the level detector 40.

[0088] As such a multiplier, that to which the suitable constant k for inverse number of differential coefficient of f(Y) = beta-Y alpha 1/f' (Y) was applied, for example, and k/f' (Y) can be used.

[0089] According to this example, even if the multiplier in the case of dynamic range compression changes with images, since a RF is always emphasized to the same extent from a low brightness region to a high brightness region, a good image with contrast is obtained.

[0090] In addition, although the filtering property is changed according to the location of each pixel in 1 image according to the description of the picture signal in one image, you may make it change a filtering property in the above-mentioned example to the picture signal of the image with which plurality differs according to the description of each image.

[0091] Moreover, in each example, although the filter and the edge detector were considered as the configuration of a single dimension, of course, it is good also as a 2-dimensional configuration. Although it becomes very complicated [the configuration of a two-dimensional filter], it can realize comparatively easily by using DSP for picture signal processing.

[0092]

[Effect of the Invention] As explained above, according to this invention, the image with which the effect of lighting unevenness was effectively reduced, and latitude has been improved can be obtained, without causing

unnatural emphasis in the edge part of an image.

[Translation done.]

* NOTICES *

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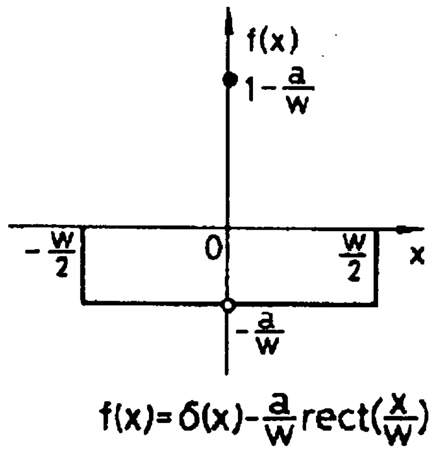
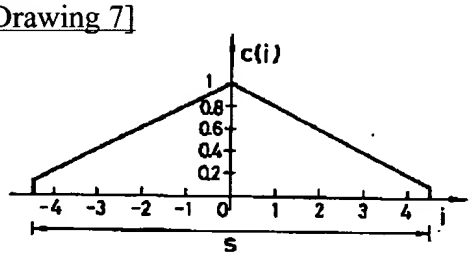
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

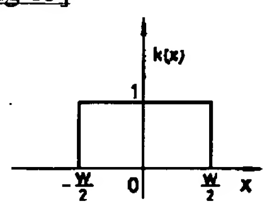
[Drawing 3]



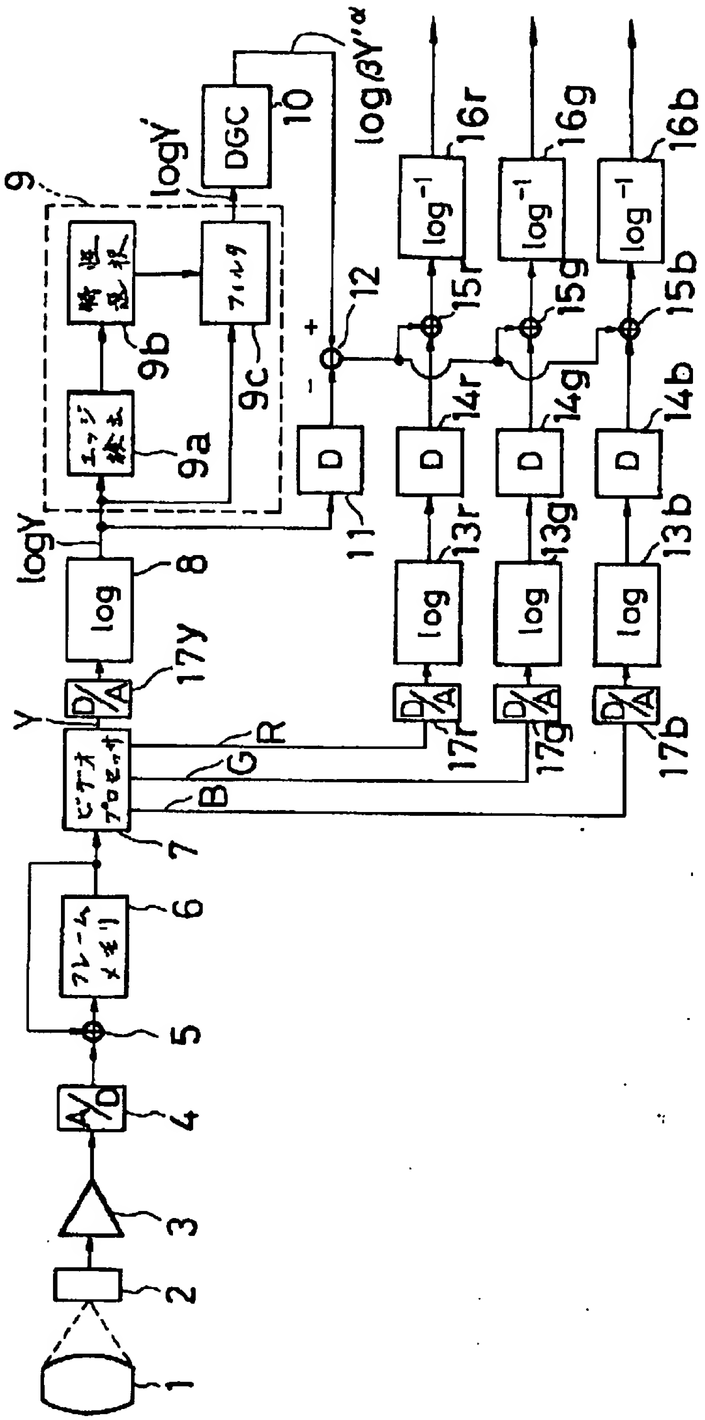
[Drawing 7]



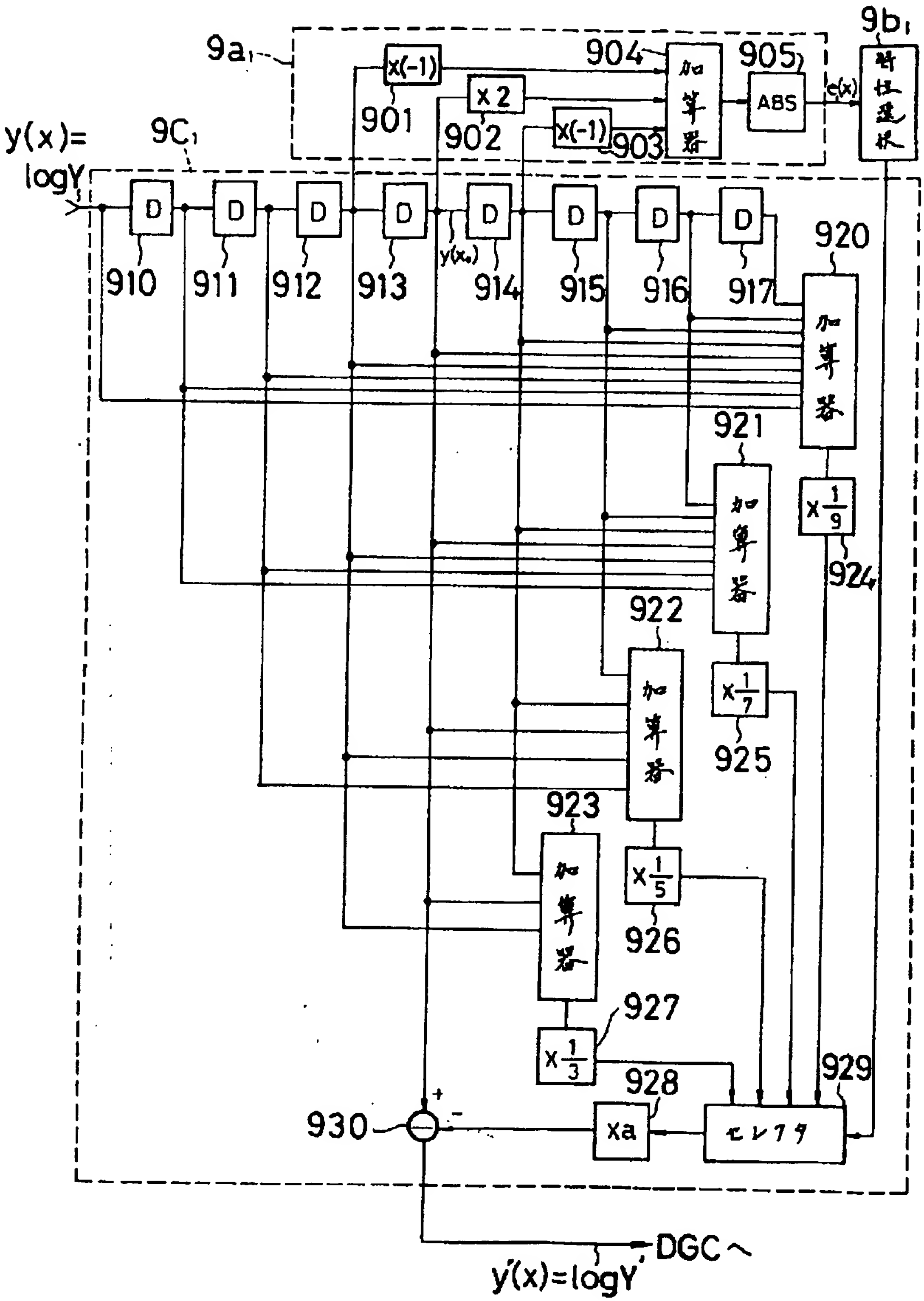
[Drawing 13]



[Drawing 1]



[Drawing 2]



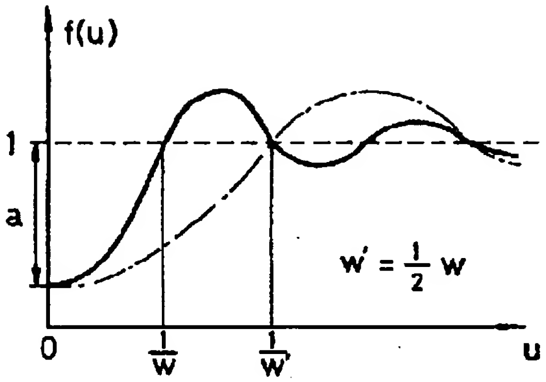
[Drawing 26]

$$\begin{matrix} \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \end{matrix}$$

[Drawing 27]

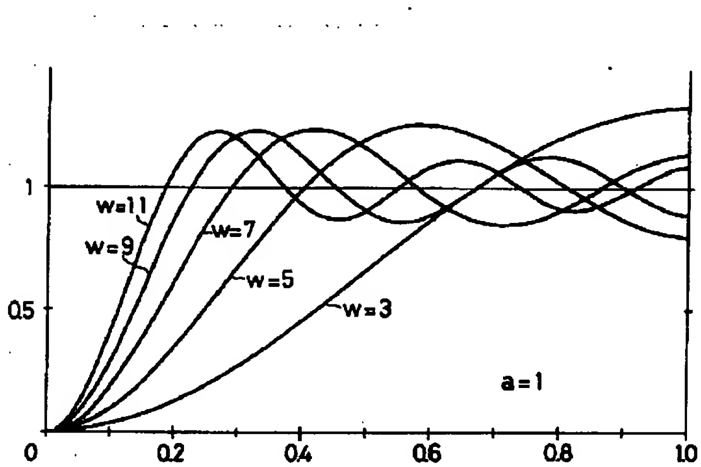
$$\begin{matrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{matrix}$$

[Drawing 4]

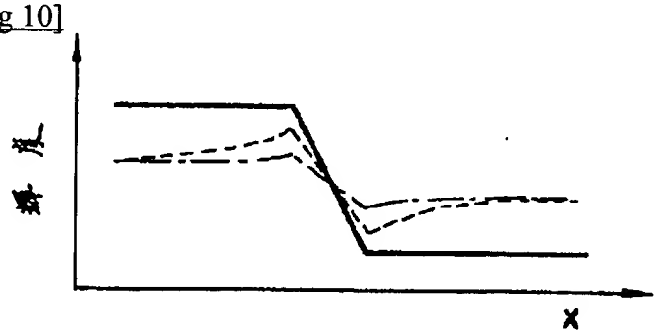


$$f(u) = 1 - a \cdot \mathrm{sinc}(wu)$$

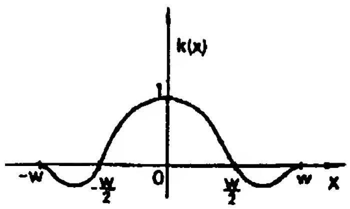
[Drawing 5]



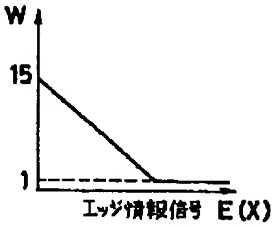
[Drawing 10]



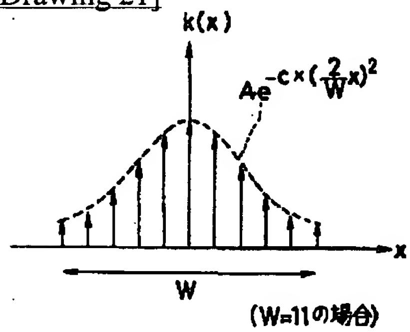
[Drawing 14]



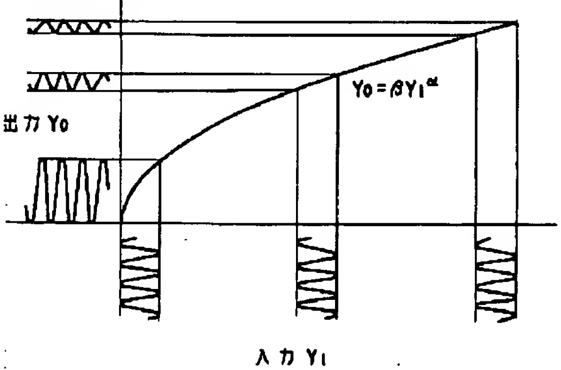
[Drawing 20]



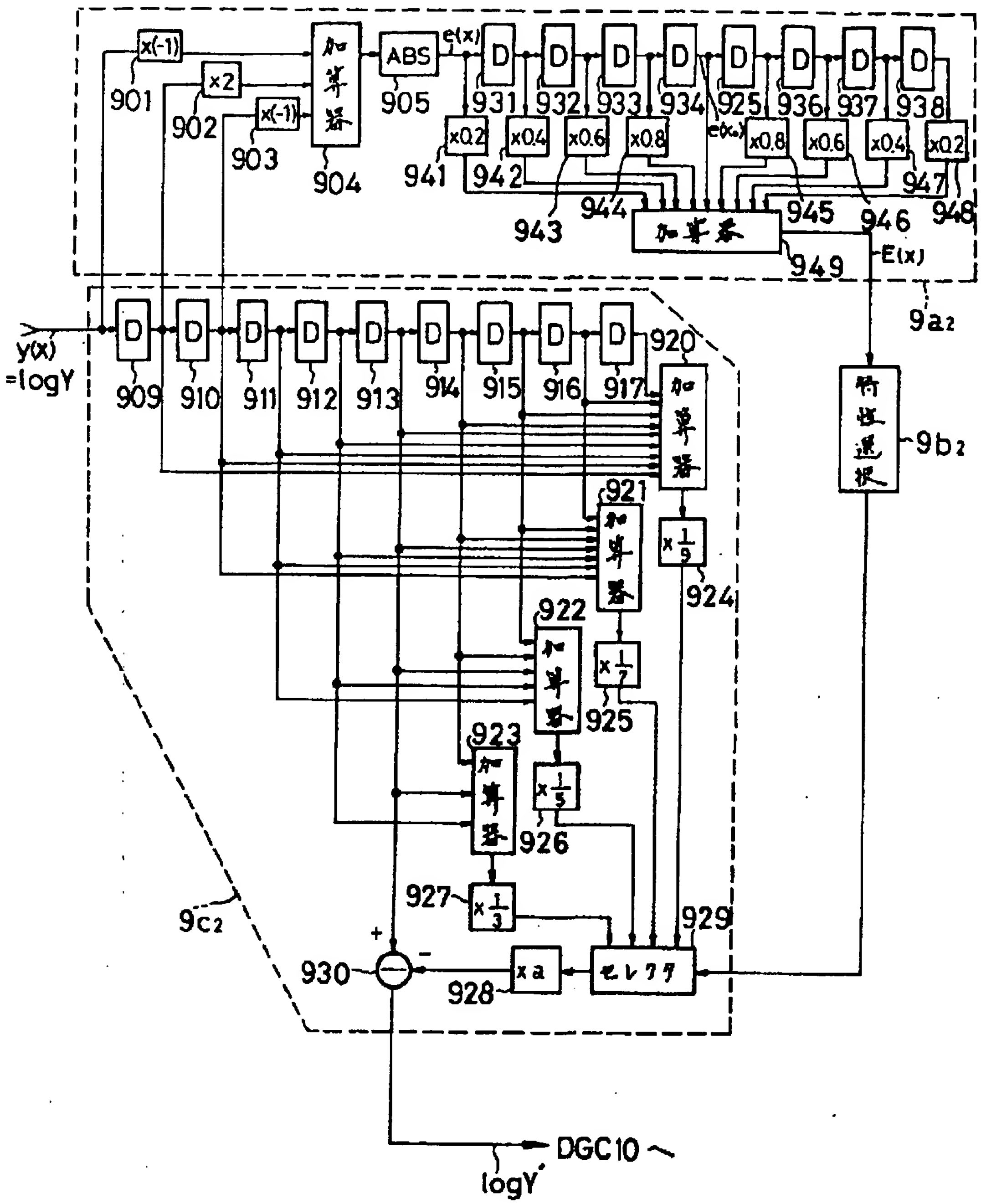
[Drawing 21]



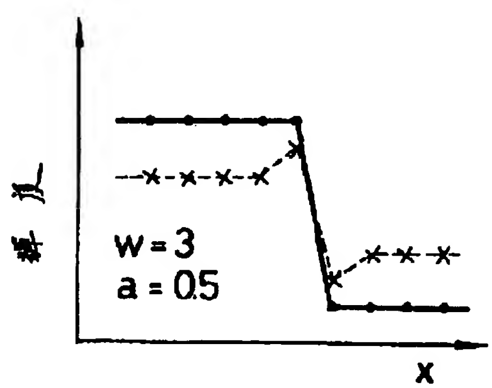
[Drawing 28]



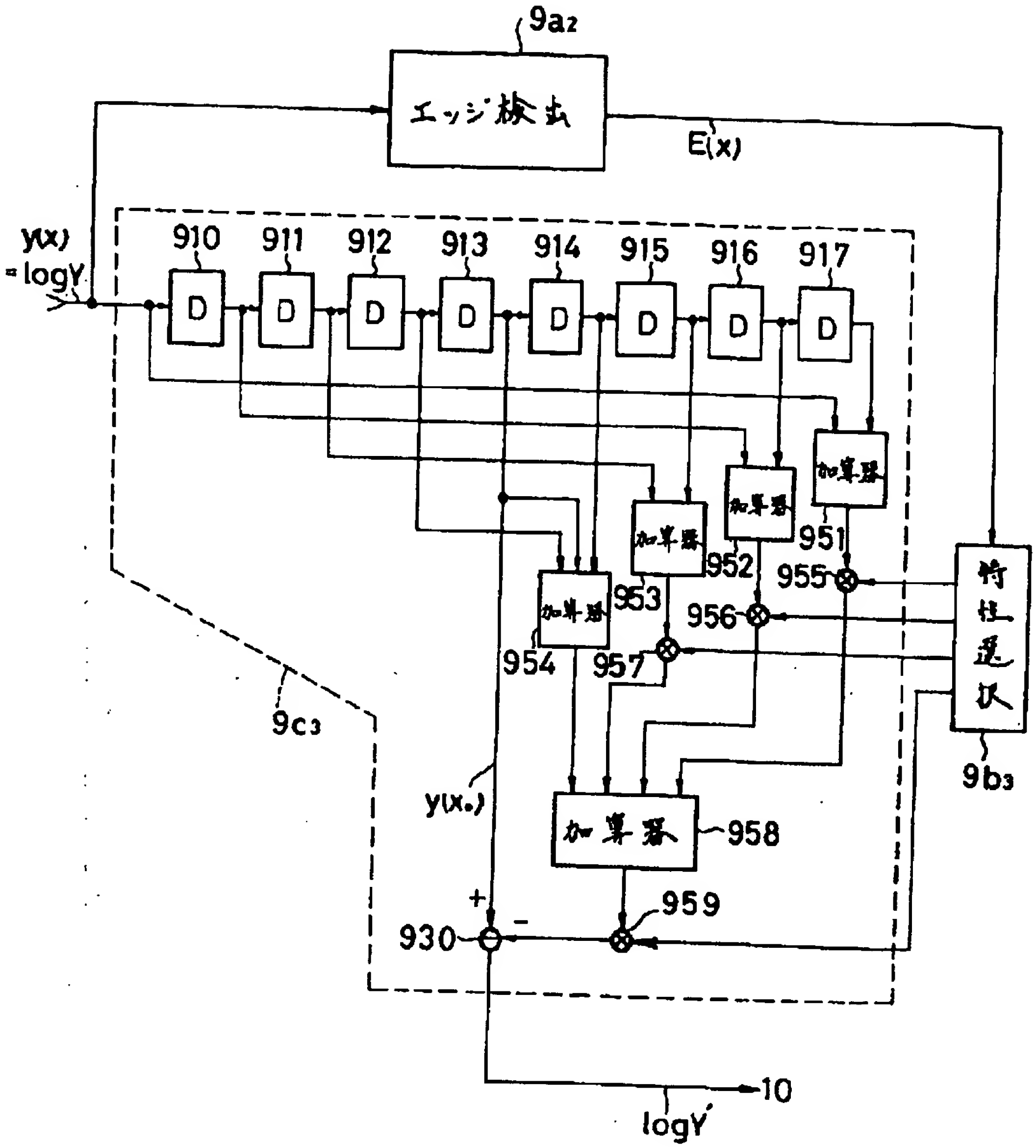
[Drawing 6]



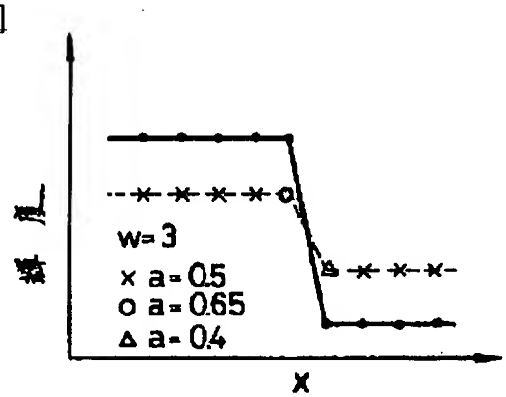
[Drawing 11]



[Drawing 8]



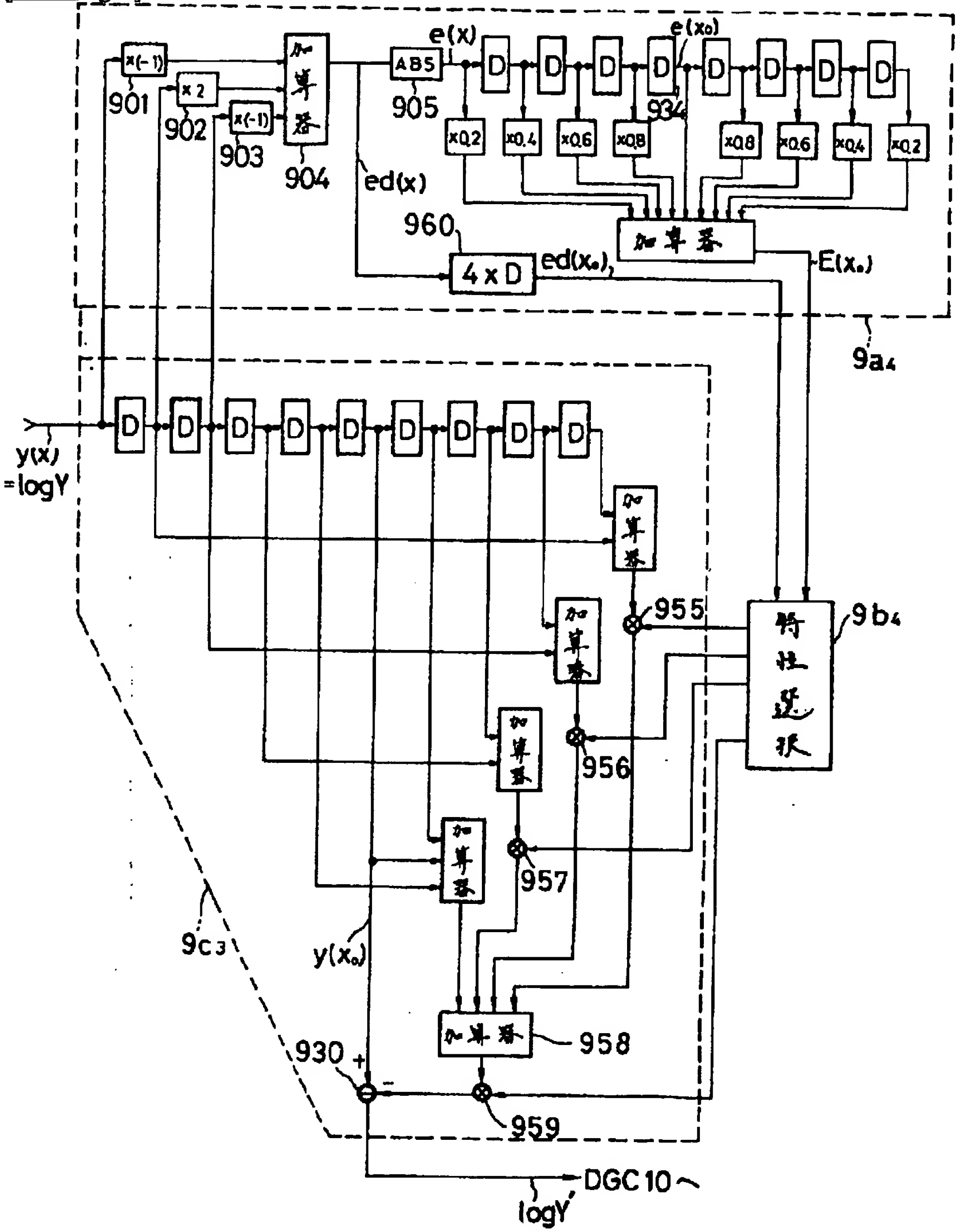
[Drawing 12]



[Drawing 15]

	エッジ情報信号 E(x) 小←→大			
局所平均幅	9	7	5	3

[Drawing 9]



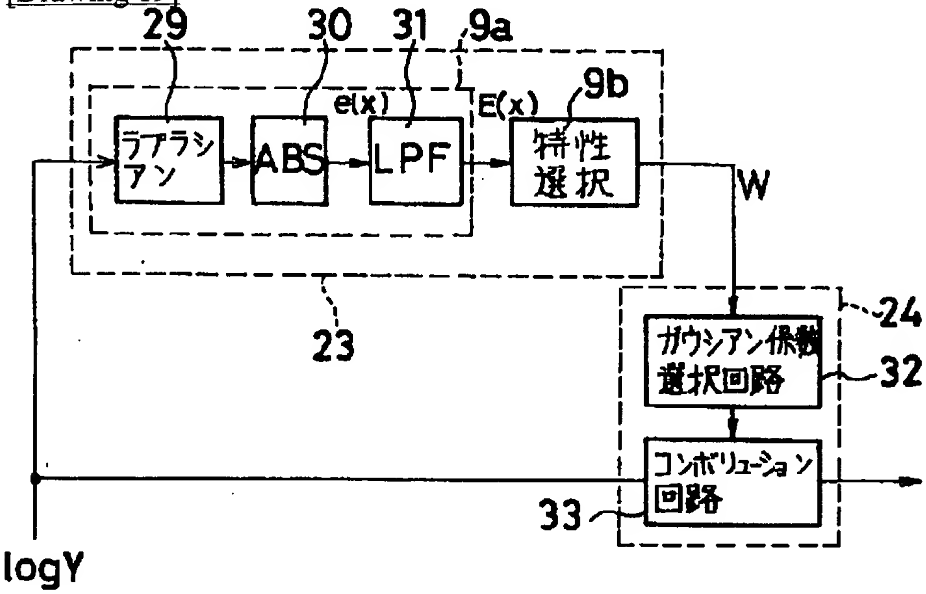
[Drawing 17]

	エッジ方向信号ed(x) 小 ── 0 ── 大
係数aの値	0.3 ── 0.5 ── 0.7

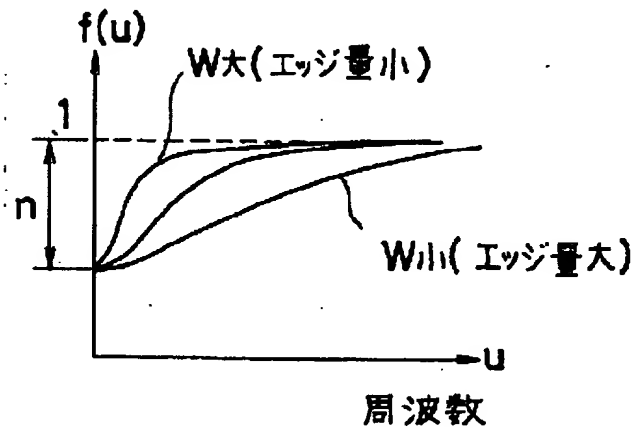
[Drawing 16]

	エッジ情報信号E(x) 小 ←→ 大			
乗算器955への出力	1	0	0	0
乗算器956への出力	1	1	0	0
乗算器957への出力	1	1	1	0
乗算器958への出力	$\frac{a}{9}$	$\frac{a}{7}$	$\frac{a}{5}$	$\frac{a}{3}$

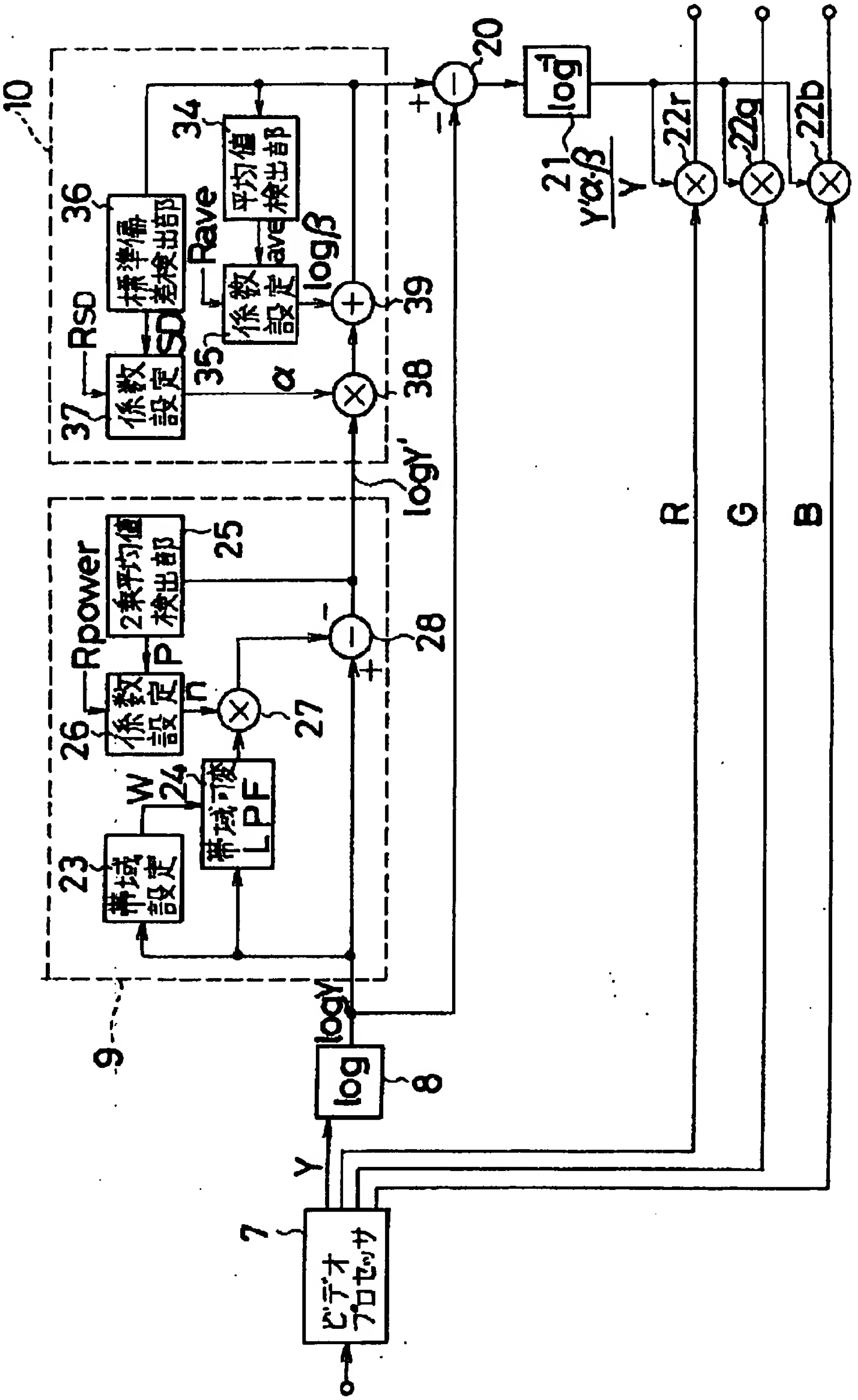
[Drawing 19]



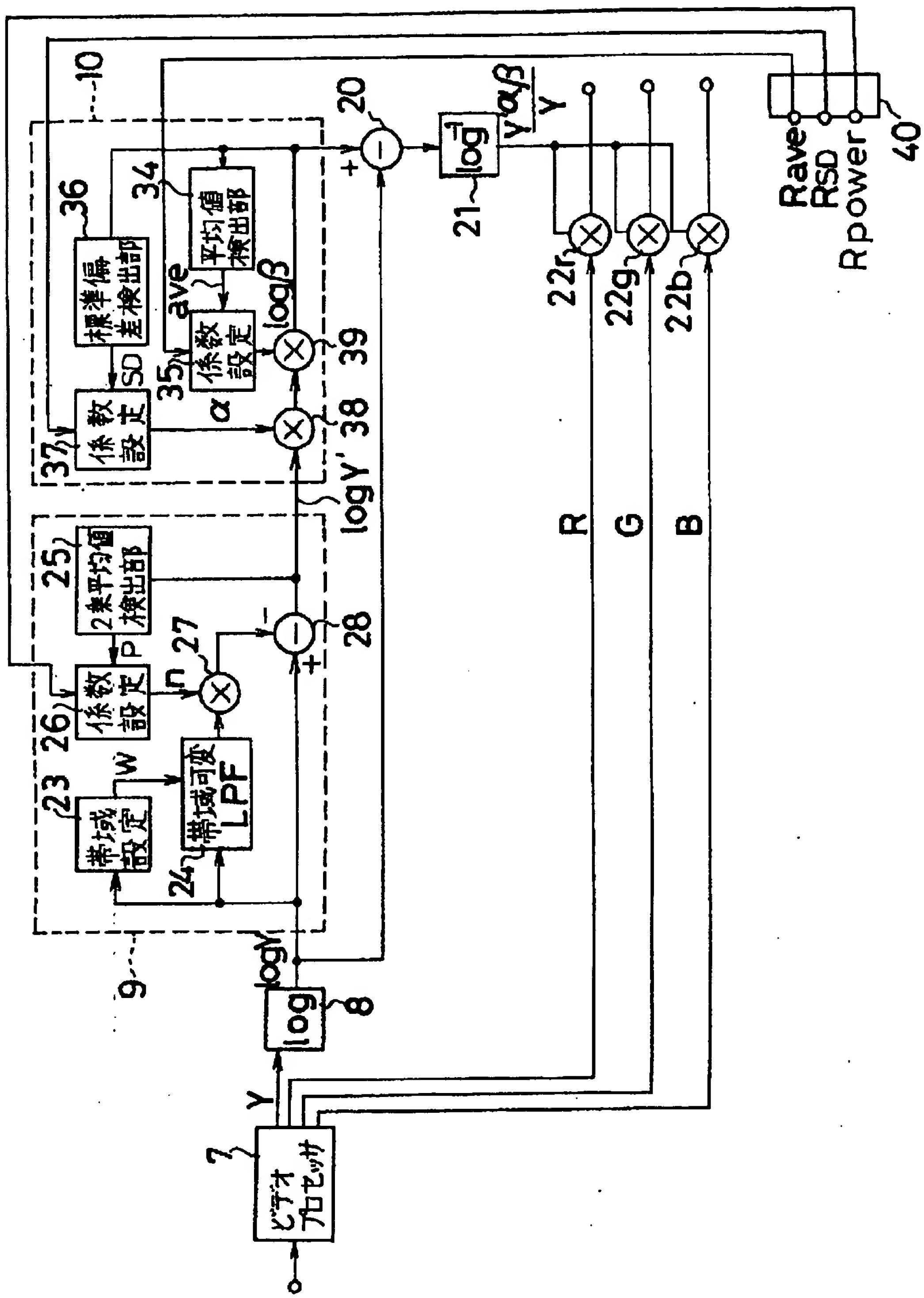
[Drawing 22]



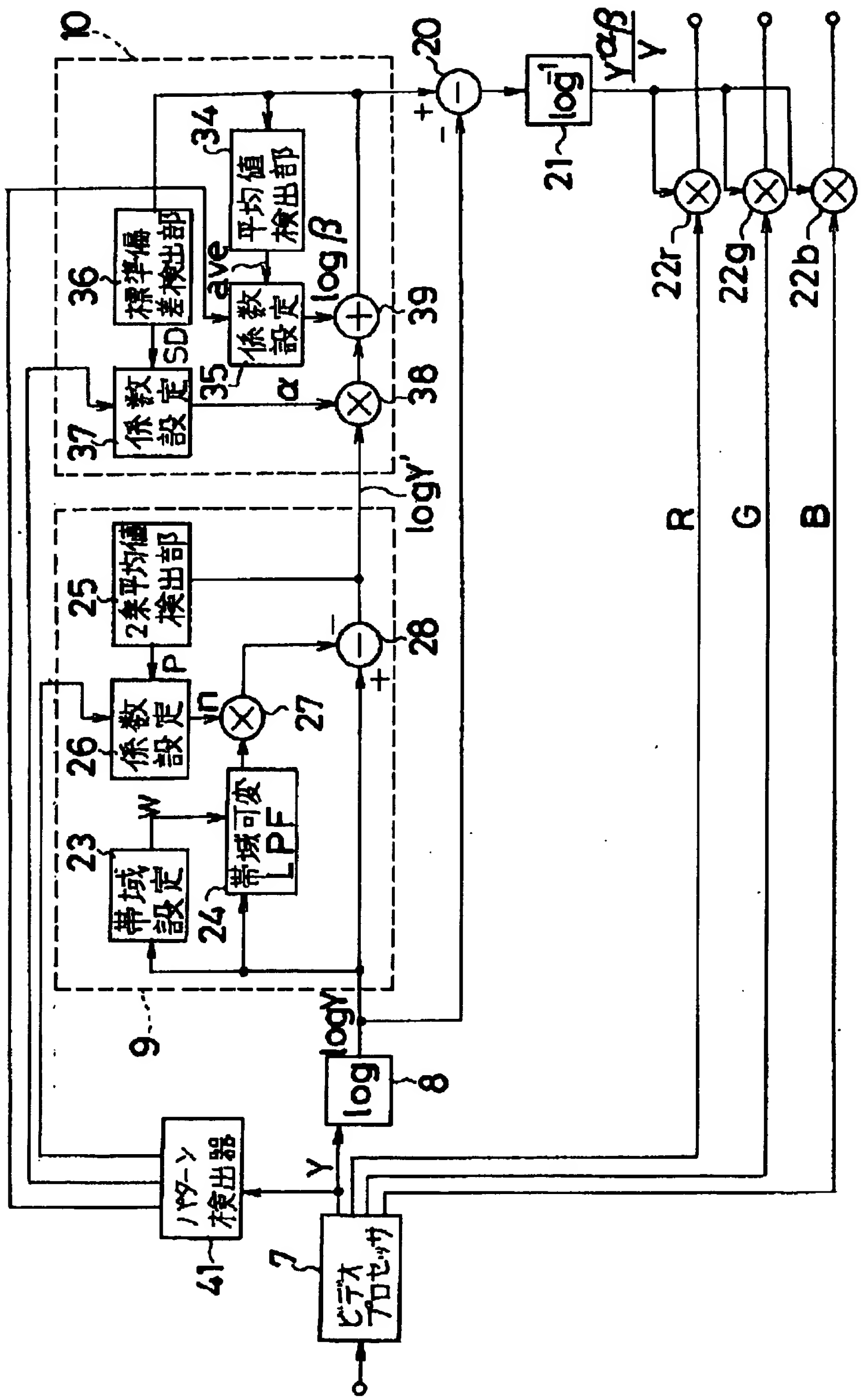
[Drawing 18]


ビデオプロセッサ
7
Y
log
8
logY
9
10
帯域設定
23
W
帯域可変LPF
24
係数設定
26
n
27
Rpower
P
2乗平均値検出部
25
28
logY'
係数設定
37
RSD
SD
標準偏差検出部
36
係数設定
35
Rave
ave
平均値検出部
34
α
38
logβ
39
20
log-1
21
Y'α·β/Y
Y
R
G
B
22r
22g
22b

[Drawing 23]

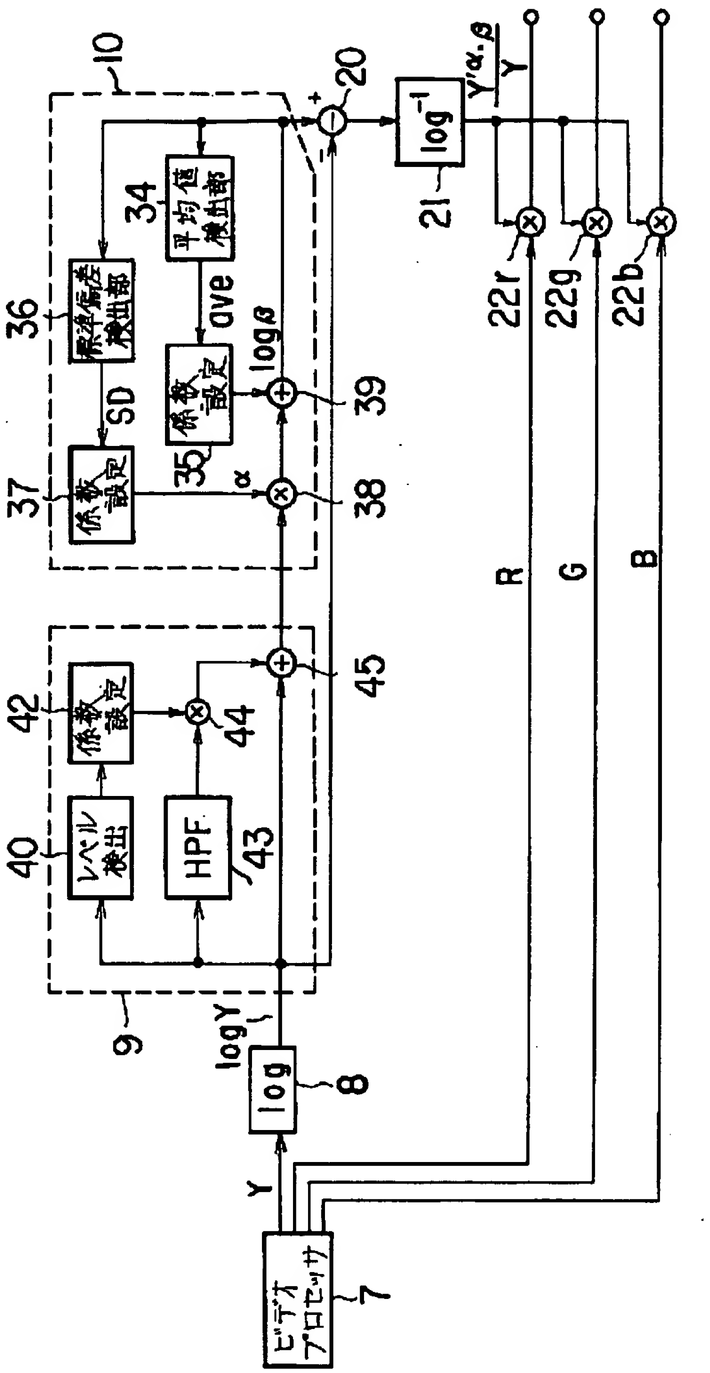

ビデオプロセッサ
log
logY
帯域設定
帯域可変LPF
係数設定
2乗平均値検出部
W
P
n
logY'
標準偏差検出部
平均値検出部
係数設定
係数設定
SD
ave
α
logβ
log⁻¹
Rave
RSD
Rpower
R
G
B
Y

[Drawing 24]



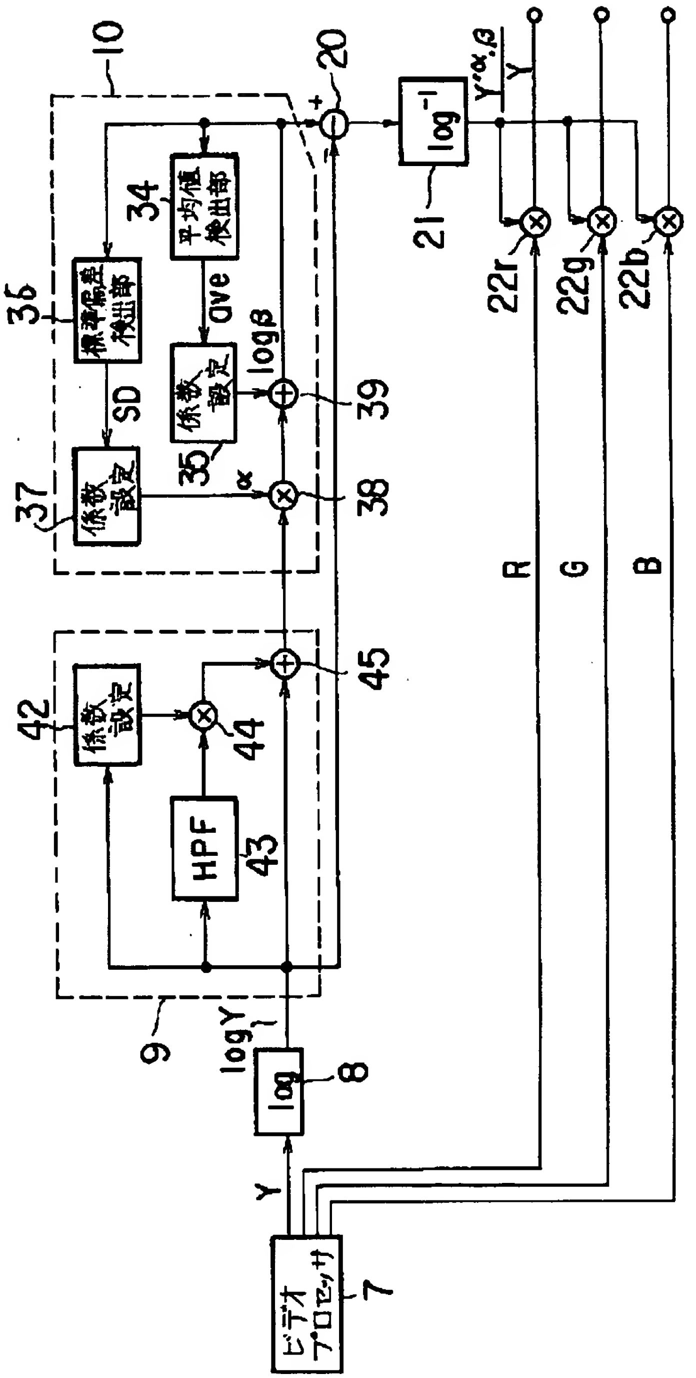
ビデオプロセッサ
パターン検出器
log
logY
帯域設定
帯域可変LPF
係数設定
2乗平均値検出部
標準偏差検出部
平均値検出部
係数設定
係数設定
logY'
log β
ave
SD
α
P
W
Yn
log⁻¹
R
G
B
22r
22g
22b
7
8
9
10
20
21
23
24
25
26
27
28
34
35
36
37
38
39
41

[Drawing 25]



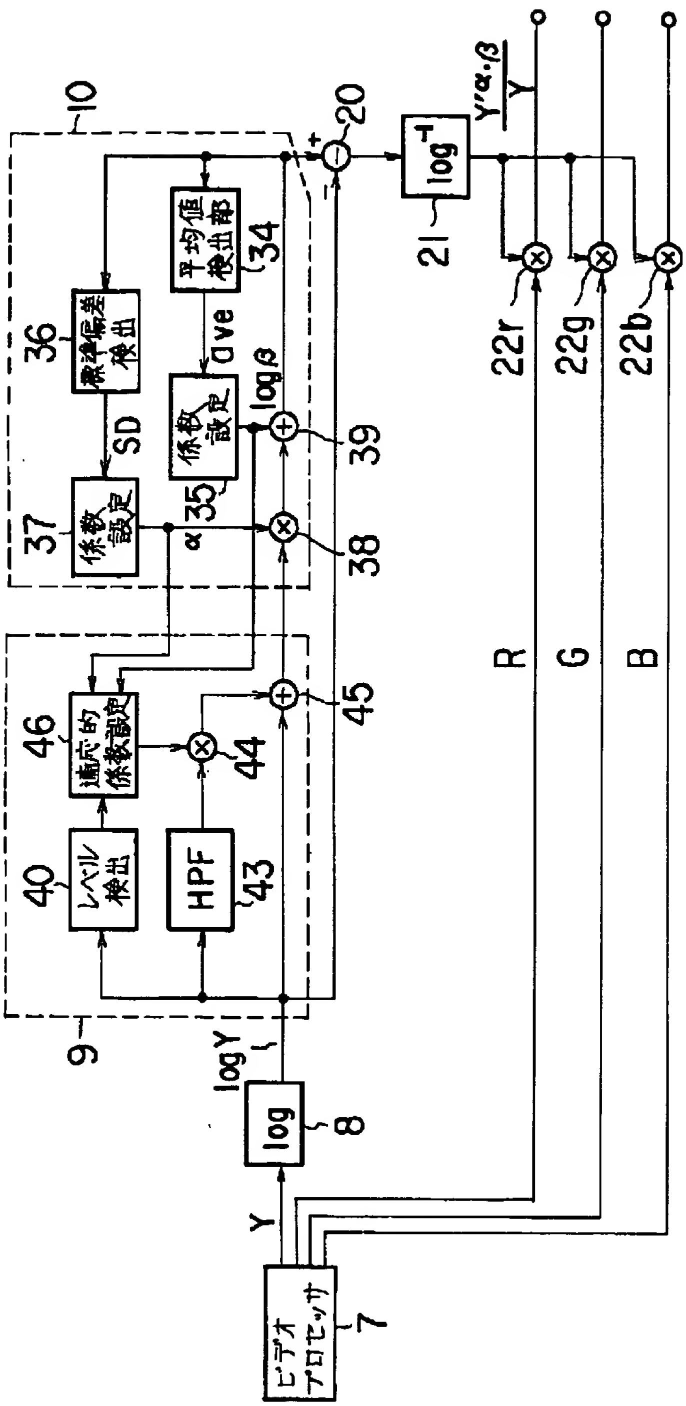
ビデオプロセッサ
log
logY
レベル検出
HPF
係数設定
標準偏差検出部
平均値検出部
SD
ave
logβ
α
log⁻¹
R
G
B

[Drawing 29]



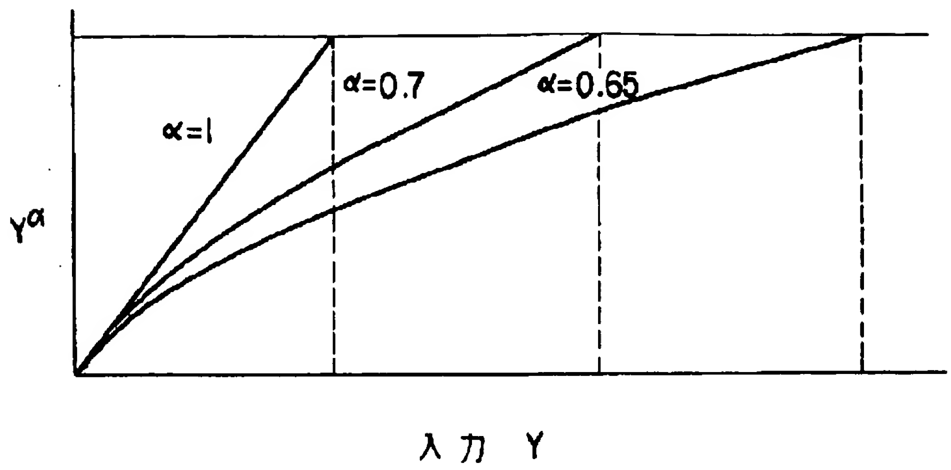
ビデオ
プロセッサ
7
Y
log
8
logY
9
HPF
43
係数
設定
42
44
45
10
係数
設定
37
標準偏差
検出部
36
SD
α
38
平均値
検出部
34
ave
係数
設定
35
logβ
39
20
log⁻¹
21
R
G
B
22r
22g
22b

[Drawing 30]



ビデオ
プロセッサ
7
Y
log
8
logY
9
40
レベル
検出
HPF
43
46
適応的
係数設定
44
45
10
36
標準偏差
検出
SD
37
係数
設定
α
38
34
平均値
検出部
ave
35
係数
設定
logβ
39
20
+
−
log⁻¹
21
$\frac{Y^{\alpha}\cdot\beta}{Y}$
R
G
B
22r
22g
22b

[Drawing 31]



[Translation done.]